The Chinese Windlass

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TOOLS:

- Drill (1)
- Drill bit (1)
- Spade bits (1)
- Thread tap (1)

PARTS:

- PVC pipe (1)
  You can substitute ABS pipe and fittings for the PVC.
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- PVC end cap (1)
- PVC end cap (1)
- PVC reducer fitting (1)
- Bolt (1)
- Bolt (1)
- Pulley (1)
- Lifting hook (1)
- Iron pipe (1)
  both ends threaded
- Iron pipe elbows (2)
- Iron pipe nipples (2)
- Iron pipe end caps (2)
- Cord (1)

- Board (1)
  for the base and 2 uprights. You can substitute 1×6 boards.
- Boards (2)
  for the base and 2 uprights. You can substitute 1×6 boards.
- Plywood (2)
  for the gussets
- Wood screws (6)
- Deck screws (6)

SUMMARY

In the summer of 1860, the Second Opium War was reaching its climax. Three years earlier, Britain and France had invaded Canton, China, in order to expand their trade in such unsavory commodities as opium and indentured servants. Chinese Emperor Xianfeng had resisted the outsiders, and a low-intensity war continued in fits and starts.

The European nations, tiring of the expense and anxiety of fighting a war so distant, launched an invasion fleet carrying nearly 18,000 men. After landing at the port of Beitang, the soldiers fought their way westward into Peking (now called Beijing) in October 1860. Not long after, a treaty was signed and an uneasy peace was restored.

Some British soldiers, encamped on the outskirts of Beijing in the aftermath, took note of an ingenious device being used to raise and lower drawbridges throughout the city.

The device consisted of a lifting hook suspended from a broad windlass made from cylinders of unequal diameters. The lifting hook was connected by an enormous length of rope, which came off one side of the windlass, went around the hook, and was coiled onto the other side when the mechanism was operated.

The soldiers observed that this windlass was capable of lifting huge loads with little effort. It soon became well known among Western engineers as the Chinese windlass.

How it works

The Chinese windlass, also known by its more descriptive name, the differential windlass, is

easy to construct and produces enormous mechanical advantage.

The lifting power comes from the way the rope is wound around 2 drums of slightly different diameters, on the same axis. When the handle is turned to lift the load, the rope is paid off the smaller drum and onto the larger.

The larger drum winds up a bit more rope than is unwound from the smaller. It's by this small difference in length, divided by 2, that the load is raised with each turn of the handle. So, while raising the load is very slow and requires many turns of the handle, what's lost in speed is gained in power. With drums of slightly differing diameter, even the smallest person can lift a very heavy load.

For the engineer or physicist, there's a simple formula that computes the mechanical advantage or "purchase" that the windlass provides:

$R/r*C/D*2=P$

Where

R = Radius of the crank handle

r = Radius of the large barrel

C = Circumference of the large barrel

D = Difference in circumference between the large and small barrels

P = Purchase (mechanical advantage gained)

Suppose we built a Chinese windlass with a 6" crank handle and 2 steel-pipe barrels, one with a 2¾" diameter and the other 3" in diameter. Could we lift a 600lb engine block?

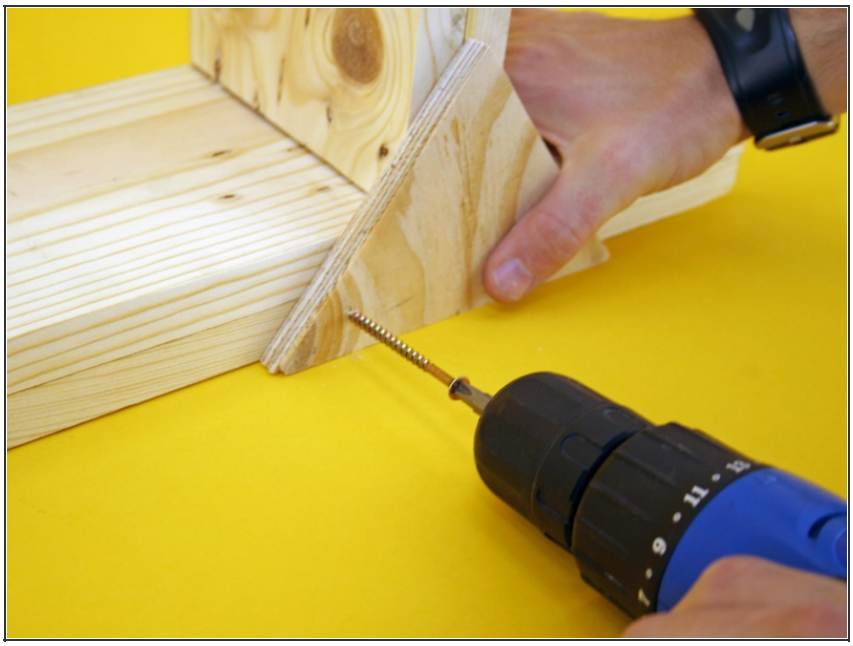
$6/1.5*3\pi/3\pi-2.75\pi*2=96$

Yes, we could lift a 600lb block with 12½lbs of force, or just 1/48 the effort of getting underneath and using our backs. Quite a bit easier indeed!

Step 1 — Build a Chinese windlass

- If you have access to a metal turning lathe, you can machine a high-capacity windlass from a 3"-diameter steel bar mounted on bearings, with one end turned to a slightly smaller diameter.
- But if you don’t have a lathe, you can easily construct a Chinese windlass demonstration model from PVC and iron pipe, pipe fittings, and a few odds and ends commonly found around the workshop or the hardware store.
- Drill a 7/8" hole in the center of each end cap.
- Assemble the windlass barrel using PVC primer and cement. (Check the diagram pdf in the documents area for more detail.)

Step 2



- Drill two 7/32" holes in the PVC pipes. Take care to drill them straight into the center of the pipe, because the ¼" bolts that go in them will act as setscrews against the iron pipe inside, allowing the windlass assembly to rotate when the crank is turned.
- Tap the holes with a ¼" tap.
- Drill a 1" hole in each wooden upright as shown in the windlass assembly diagram. Fasten one of the uprights to the base using three 2½" deck screws.
- Insert the iron pipe into the PVC windlass barrel through the holes in each PVC end cap. Center the barrel on the pipe.
- Insert one end of the pipe into the hole in the upright attached to the base. Slide the other upright into place and attach it to the base using three 2½" deck screws.
- Attach the wooden gusset plates to the base and uprights using 3 wood screws per gusset.

Step 3



- Screw the 2 iron pipe elbows and 2 nipples onto the pipe to form a crank. Add end caps to the open pipe ends.
- Insert the ¼" bolts into the tapped holes on the windlass and tighten them gently until they bottom on the iron pipe.
- Attach the cord, pulley, and hook as shown in the first and last photos, tying off the cord on the ¼" bolts. Your Chinese windlass is ready for use!

Troubleshooting: Be sure the ¼" bolts are set firmly against the iron pipe, otherwise the crank won't turn the windlass. If the bolts slip, use a metal file to make flat spots on the pipe to help them hold better.

If they still slip, or if you want to lift more weight, put a pencil through the bolt holes to mark the iron pipe, then drill and tap holes in the iron pipe as you did the PVC, and screw the bolts into the iron pipe.

Make certain the rope is wound as shown in the photos. The system won't provide mechanical advantage if the rope isn't arranged correctly on the windlass.

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